UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES
Center for Aquatic Weeds

AQUAPHYTE

International Plant Protection Center
AQUATIC WEED PROGRAM

VOLUME 5, NUMBER 1 GAINESVILLE, FLORIDA SPRING 1985

AQUATIC PLANTS AND DISEASES

Schistosomiasis, malaria, yellow fever, filariasis, encephalitis, fascioliasis and paramphistomiasis are diseases which continue to afflict man and his livestock. They are endemic in parts of Africa, Asia and South America where they cause immeasurable health and economic losses. These diseases have another thing in common: their vectors are snails and mosquitoes which are closely associated with certain aquatic plants. For many years, health officials have attempted to control these diseases by the use of insecticides and molluscicides against the vectors. Another way to effect disease control might be to control the aquatic plants which are essential to the life-cycles of the vectors. The Aquatic Weed Program database was searched for information about disease vectors associated with aquatic plants. The search revealed the following information.

Schistosomiasis ("bilharzia") is one of the major diseases of the world, afflicting more than 200 million people. Incidence of this water-based parasitic disease is increasing. The flatworm parasite's larvae swim from their snail hosts to the skin of humans and animals in infested waters. They enter the skin and through the bloodstream find their way to several internal organs. There they multiply, debilitating their victims with a variety of ailments, and eventually can cause death.

Malaria, yellow fever, encephalitis and other diseases are carried by certain species of mosquitoes and also affect millions of people and animals.

Control of these diseases has been limited mostly to the use of molluscicides and insecticides to control snails and mosquitoes but their effectiveness has been questioned. Millions of pounds of DDT, for example, have been used inside homes for years to control the malaria mosquito vector *Anopheles darlingi*. But in one study, DDT use in Suriname homes reduced the *A. darlingi* biting rate by only 20% (Hudson, 1984). Others have concluded that DDT cannot eradicate malaria or *A. darlingi* (Gabaldon, 1952). Under certain conditions such as fast flowing water or extensive plant coverage, other pesticides often are ineffective when applied at recommended rates. Neogy *et al.*(1957), for example, found that larvicidal control of mosquitoes was ineffective because of the rapid growth of aquatic flora which gave refuge to mosquito larvae.

Thomas and Tait (1984) suggested possible controls for snail vectors including "bioengineering" such as ditching, draining, dredging, transplanting, introducing non-host competitive species, and controlling aquatic plants with fishes, domestic animals and mechanical barriers. And there is much published aquatic plant control research, including studies on herbicidal, biological and mechanical aquatic plant control.

While studies have been made on plant-pest relationships, very little research has been published about the effects of plant control on pest snail and mosquito populations. Researchers agree that certain aquatic plants are essential to the life-cycles of disease-vector snails and mosquitoes, but few can say how controlling these plants would affect the numbers of snails and mosquitoes.

SNAILS

Biomphalaria glabrata and *Bulinus truncatus* are vectors of schistosomiasis. Other snails which carry helminthic diseases are *Lymnaea auricularia, L. luteola, Indoplanorbis exustus*, and *Austropeplea vinosa*.

Snails and aquatic plants have evolved together for 500 million years. Plants provide food (including plant tissue and epiphytes), oxygen, egg-laying sites, and protection against predators (Thomas, 1983). Aquatic host-plants for snails include *Ceratophyllum demersum*,

(Continued on page 6)

INSECTS AND HERBICIDES WORKING TOGETHER

Integrating methods of control could reduce costs and simplify control of some aquatic weeds. For example, dense infestations of water hyacinths could be quickly reduced by chemical or mechanical means, then biological agents could remain on the job to keep the plants from proliferating again.

Before biological controls and herbicides can be used together, studies must be made to determine their compatibility. To do this, entomologist Dr. Kim Haag, has begun several large-scale pond tests to determine the efficacy of the integrated use of herbicides and insects to control water hyacinths. Various formulations of 2,4-D will be used together with *Neochetina eichhorniae* and *Neochetina bruchi*, two water hyacinth weevils.

In previous tests, Haag gauged direct toxicity of herbicides to weevils and recorded behavioral responses of insects on plants sprayed with herbicides. In the toxicity tests, weevils on plants were sprayed with commonly used formulations of 2,4-D, diquat and glyphosate. Haag found no significant mortality of weevils sprayed with any of the herbicides. However, she did find that some of the inverting oils were toxic to weevils.

In behavioral trials, weevils were marked and placed in different parts of water hyacinth mats which had been partially-treated with herbicides. Haag recorded the movements of the different groups of weevils and concluded that there were no acute behavioral responses to herbicide application. The insects, which prefer healthy plant material, eventually migrated from the sprayed areas after the plants had yellowed and died.

The large-scale tests underway will help determine if, in natural situations, weevils would maintain their populations by migrating to those plants which were not killed by herbicide application.

Haag's work is funded by a USDA Cooperative Agreement through the University of Florida Center for Aquatic Weeds. Her address is: Dr. Kim H. Haag, Entomology Department, Bldg. 339, University of Florida, Gainesville, Florida 32611. (904) 392-4901.

SONAR STUDIES

The effects of exposure period and light on Sonar (fluridone) uptake and efficacy are being measured in tanks planted with three plant species and hydrilla tubers. Sonar is a new experimental herbicide formulated by Eli Lilly & Co. for hydrilla control. Conducting the tests is Mr. Daniel Thayer, assistant in aquatic weeds at the Center for Aquatic Weeds.

Mortality and dryweight of plants in test and control tanks will be compared to determine how shading and increased exposure times affect plant control at standard herbicide application rates. Plants used in these tests are *Hygrophila polysperma, Hydrilla verticillata* and *Potamogeton illinoensis.*

In separate aquatic raceways, hydrilla tubers are being studied for their uptake of Sonar in flowing waters. These tests will help determine if Sonar can be used effectively against hydrilla tubers in canals as a preemergent herbicide early in the growth season. Controlling tubers is a major goal of aquatic plant managers which could seriously affect the ability of hydrilla to infest and spread.

AQUATIC PLANT CONTROL LAWS

Florida has had infestations of water hyacinths (*Eichhornia crassipes*) since they were introduced into the state in the 1890s. Since then, alligatorweed (*Alternanthera philoxeroides*) and hydrilla (*Hydrilla verticillata*) have become nuisance plants as well. Several other exotic and native plants in Florida have the potential to become major "economic weeds". Because of economic and other impacts of these aquatic weeds, the U.S. and Florida governments have passed legislation intended to help control them.

The Florida legislature has stated "the uncontrolled growth of non-indigenous aquatic plants in the waters of Florida poses a variety of environmental, health, safety and economic problems...it is the responsibility of the State to cope with the uncontrolled and seemingly never-ending growth of nonindigenous aquatic plants...and the control of nonindigenous plants must be carried out primarily by means of maintenance programs, rather than eradication or complaint spray programs" (FSS, 372.932.)

"Maintenance control" is defined by Florida law as a method "in which control techniques are utilized in a coordinated manner and on a continuous basis in order to maintain the plant population at the lowest feasible level as determined by the Department of Natural Resources" (FSS, 372.932). Maintenance control is believed to be more economical because lower levels of plants require less control effort and cause less economic loss to users of the water resources. Maintenance control also is believed to be more environmentally safe because adverse impacts caused by exotic species and their management techniques are reduced.

The agencies and programs listed below provide the framework within which Florida manages the technical control operations and the social and political issues associated with aquatic weed management:

1) The **Bureau of Aquatic Plant Research and Control** is part of the **Florida Department of Natural Resources**. It coordinates control programs throughout the state, provides matching state funds for federal programs, and promotes and supports research activities.
2) **The Aquatic Plant Control Trust Fund** receives $3.8 million of the funds collected from state gasoline taxes, forty percent of the license fees from commercial vessels, and $2 from each noncommercial vessel registration fee (approximately $1.2 million in 1983). The fund provides a stable source of financing for aquatic plant management programs.
3) **Aquatic Plant Control Permits** are required in Florida to regulate the types of control methods and the amounts of vegetation controlled. The **D.N.R.** program, which also requires that the public be notified of aquatic weed control work done, is coordinated with the **Department of Environmental Regulation** and the **Florida Game and Freshwater Fish Commission**.
4) The importation of plants into Florida is prohibited without first obtaining a permit from the **Department of Natural Resources**.
5) **The Center for Aquatic Weeds of the University of Florida** was created by the Florida legislature to coordinate, develop and promulgate research related to noxious aquatic plants. The legislature provides sustained base-level funding for the research facility, its faculty and supporting personnel. The Center conducts research and provides educational opportunities for students and aquatic plant control personnel.
6) **The Aquatic Plant Advisory Council** is made up of agency personnel and water resource user groups, and provides recommendations on policy and procedures for aquatic plant management.

Florida State Statutes

FSS 213.11. Authorizes the **Department of Natural Resources** to receive $3.8 million from state gasoline sales taxes.

FSS 241.362. Establishes the **Center for Aquatic Weeds.**

FSS 327.28. Authorizes the **Aquatic Plant Control Trust Fund** to receive 40% of the license fees from commercial vessels.

FSS 372.925; 372.932. Vests the **Department of Natural Resources** with the authority to direct aquatic weed research and control statewide, and to disburse funds to other agencies for the maintenance control of aquatic weeds.

FSS 403.141. Establishes penalties which, among other things, applies to negligently applying aquatic herbicides or applying them without a permit. (Not more than **$10,000 per offense, per day.**)

FSS 403.271. Requires permits for importing any exotic aquatic plants or seeds into Florida; requires permits for moving or cultivating any aquatic plants within the state.

Chapter 16C-19. Rules of the **Department of Natural Resources** for obtaining permits to import, transport or cultivate aquatic plants, and lists approved and prohibited aquatic plants.

Chapter 16C-20. Rules of the **D.N.R.** for establishing and obtaining aquatic plant control permits.

Some **county governments** in Florida have their own aquatic plant control departments. They receive funding from their own tax sources, and from the state and federal governments.

The **U.S. government** also controls aquatic plants. The **River and Harbor Act of 1899** authorizes the **U.S. Army Corps of Engineers** to conduct aquatic plant research and control, and is totally federally funded. **Federal Public Laws 85-500 (1958)** and **89-298 (1965)** provided $5.0 million per year nationwide for aquatic plant control and call for a federal research program to develop economic and effective control measures and to help local participants with the cost of aquatic plant control. Congress increased the fund to $10 million per year in 1984 (**Public Law 98-63**).

Two funding programs exist through the **Army Corps Jacksonville District**: 1) Removal of Aquatic Growth Project (**RAGP**), which provides 100% funding for the protection of navigation in Federal Project waters.

2) Aquatic Plant Control Program (**APCP**), which is a cooperative program for control in navigable public waters, provides 70% of the cost of control (matched by 30% state or local funds) in lakes and rivers which have unrestricted access to the general boating public.

For more information or for copies of any of these laws, write to the agencies or to: **Aquatic Weed Program, 2183 McCarty Hall, University of Florida, Gainesville, Florida 32611, USA (904)392-1799.**

AQUATIC BIOLOGIST WANTED

An aquatic biologist is wanted by the City of Cape Coral (Florida) to set up a management program for more than 400 miles of fresh and salt water canals. The salary will be between $20,000 and $25,000. Applicants should 1) have a master's degree in aquatic biology, aquatics management or a related field and three years experience, or 2) have a bachelor's degree and five years experience. Send resume to **City of Cape Coral, Personnel Department, P.O. Box 900, Cape Coral, Florida 33910.**

MAKING AQUATIC WEEDS USEFUL: SOME PERSPECTIVES FOR DEVELOPING COUNTRIES

1976. National Academy of Sciences, 175 pages. Fifth printing 1984

This popular book has been reprinted and is now available. It reviews methods for controlling aquatic weeds and utilizing them to best advantage. It concentrates on methods which could be used in developing countries.

The book is free and is available from the Aquatic Weed Program or directly from the National Research Council, Office of International Affairs, Reports and Distribution, 2101 Constitution Avenue, Washington, D.C. 20418 USA. (202) 334-2633.

WEED SOCIETY OF QUEENSLAND

The Weed Society of Queensland (Australia) was organized to promote interest in and the investigation of all aspects of weeds and their control and to foster the development of an Australian-wide weeds organization. The Society sponsors meetings and workshops and its members receive the WSQ Newsletter. The newsletter includes informative and practical articles about weed control, and introduces to its members new weed control products such as herbicides and application equipment. There are four classes of membership. For a brochure about the Society, write The Secretary, Weed Society of Queensland, C/-P.O. Box 36, Sherwood, Queensland 4075, AUSTRALIA.

UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES
Center for Aquatic Weeds
AQUAPHYTE
International Plant Protection Center
AQUATIC WEED PROGRAM

VOLUME 5, NUMBER 1 GAINESVILLE, FLORIDA SPRING 1985

AQUAPHYTE is the newsletter of the Center for Aquatic Weeds and the IPPC Aquatic Weed Program of the University of Florida Institute of Food and Agricultural Sciences (IFAS). The International Plant Protection Center (IPPC) is a unit of Oregon State University and is funded by the United States Agency for International Development (AID). Support for the Aquatic Weed Program also is provided by the Florida Department of Natural Resources (DNR).

EDITOR: Victor Ramey

AQUAPHYTE's circulation is 4,000. It is distributed to aquatic biologists and agencies in 65 countries. Comments, announcements, news items and other information relevant to aquatic plant research are solicited.


Little Wekiva River

FLORIDA CITY FUNDS RIVER STUDY

A new three-year riverine ecosystem study is under way in Florida at the request of the **City of Altamonte Springs** and the **Friends of the Wekiva River.** Researchers of the **University of Florida Center for Aquatic Weeds** have been funded to develop a model to predict the effects of wastewater discharges on aquatic plant growth, algal export rates and other biota in the **Little Wekiva River.**

The small spring-fed river runs through residential areas receiving nutrients from municipal wastewater treatment plants, street runoff and three major springs. Parts of the river are becoming overgrown with aquatic plants including *Paspalum, Vallisneria, Hydrilla* and others. The predictive model will help determine how nutrient loading from future riverside development and additional wastewater discharge can affect the river's productivity.

The hydrology, water quality, invertebrate drift rates and fisheries potential of the river also will be studied. In addition, researchers hope to determine if the physical characteristics of the river affect its biological productivity.

Investigators for the project are **Dr. Daniel Canfield, Dr. Jerome Shireman** and **Mr. Mark Hoyer** of the Center for Aquatic Weeds. They would be interested in hearing from other researchers who have studied river eutrophication and its effects on biota. Their address is: Center for Aquatic Weeds, IFAS, University of Florida, 7922 N.W. 71st Street, Gainesville, Florida 32606 USA (904) 376-0732.

7TH INTERNATIONAL SYMPOSIUM ON AQUATIC WEEDS

The 7th International Symposium on Aquatic Weeds, sponsored by the **European Weed Research Society (EWRS)** and the **Association of Applied Biologists (AAB)**, will be held September 15-19, 1986 at Loughborough University of Technology in Loughborough, England.

The theme of the Symposium is "The Biology and Control of Aquatic Weeds". There will be sessions on regional problems and management approaches, future trends in aquatic weed control, impacts of water use on control strategies, and impacts of aquatic weed control on aquatic ecosystems and socio-economic aspects of aquatic plant management. A Proceedings will be published. Information about the Symposium and details for authors and exhibitors can be obtained from **Dr. Max Wade, Department of Human Sciences (Ecology Group), Loughborough University of Technology, Loughborough, Leicestershire LE11 3TU, ENGLAND.**

HERBICIDE ADVANCED SHORT COURSE

Aquatic herbicide registration, regulation, toxicology, and safe use were the topics of the recent Aquatic Plant Control Advanced Short Course. More than 120 aquatics managers, chemical industry representatives, and state and federal government personnel participated in the seminar, which was co-sponsored by the University of Florida Center for Aquatic Weeds (Dr. Joseph Joyce, Director) and the Florida Aquatic Plant Management Society.

Dr. William Becker, IFAS safety specialist, began the program by saying that the two primary concerns of pesticide programs are the protection of people and the protection of the environment. He recommended policies and procedures for storing, handling, mixing, loading and disposing of pesticides, saying that only through adequate supervision can pesticide programs continue to have good safety records. He said that of 4,000 to 5,000 poisoning deaths a year in the U.S., only 20 to 40 of them are pesticide related.

The U.S. Environmental Protection Agency's Mr. Roy Clark canvassed participants on studies they would require before registering a product (or re-registering an old one). The participants wanted product chemistry studies, residue and persistence studies, toxicity studies including acute effects, effects from sub-toxic and chronic amounts, effects on reproduction, mutagenicity studies, effects on non-target organisms, efficacy of the product, tolerances for water and for wildlife, and more. Clark then listed and described the studies EPA does require before registration is granted. The two lists were nearly identical. EPA requires 27 product chemistry studies, 23 residue studies and 7 toxicology series studies.

Clark also discussed product labeling, saying that labels are loaded with information about the product, and in the U.S., have the force of law. Labels are inconsistent in their formats, however, and managers and applicators often find it difficult to identify quickly needed information on different labels. He said that an EPA task force now is studying ways to improve label uniformity and usability.

Senior product toxicologist Dr. Tim Long of Monsanto Chemical Company described in detail the toxicology studies his and other companies conduct on their products, as required by law. In acute tests, high level doses (meant to "force" toxic effects) are administered to groups of animals (rats, mice and dogs) and short-term gross effects are studied. In subacute tests, animals are repeatedly administered various doses for 30-90 days. In chronic exposure tests, animals are repeatedly exposed for their lifetimes. The potential of a product to affect reproduction in several generations is studied, as is the ability of a product to alter genetic material in cells.

According to Long, these tests take two to four years and cost $2-3 million. He said the product patent life is 17 years, and often 10 of those years are taken in studies and other pre-registration requirements, leaving 7 years to recover development costs and become profitable. With some products, especially aquatic herbicides which account for only a small portion of chemical company sales, testing and registration costs have little chance of being recovered during their patent lives. This often makes new aquatic herbicides uneconomical to produce.

Short course participants also heard Dr. Daniel Canfield of the U.F. Center for Aquatic Weeds review the short history of the science of limnology, and explain trophic classifications of water-bodies. Using facts and figures from his extensive studies of Florida lakes, Canfield demonstrated the effects of aquatic plant removal on nutrients, chlorophyll, transparency and other ecosystem parameters, in relation to hydrology, climate, geology and water body morphology. For example, he pointed out that long-term rainfall cycles can affect aquatic plant data interpretation, but sometimes researchers do not take rainfall into account. This can result in faulty conclusions. Canfield also stressed that the "management objectives" of a water body must be established before the system can be successfully manipulated. He concluded that maintenance control of aquatic weeds makes it easier to keep the ecosystem in balance than when aquatic weeds are allowed to proliferate.

The Center's Dr. William Haller described the toxicity and fate of the most commonly used herbicides in Florida (copper, diquat, endothall, 2,4-d, glyphosate and fluridone). He discussed potable water and aquatic animal tolerances and compared these tolerances to the appropriate herbicide rates used for controlling aquatic plants. In all cases, he said, effective plant control rates are well below the tolerance rates set for water and aquatic animals.

A panel discussion among chemical company personnel was moderated by Mr. Carlton Layne of the E.P.A. Panel members suggested changes to herbicide labels and discussed their interpretations of rules and regulations.

Additional advanced short courses are being planned concerning other aspects of aquatic plant management.

Sign in Biscayne Bay, Florida

AQUATIC PLANT JOURNALS

There are two journals which should be of particular interest to aquatic plant researchers and to managers of aquatic plants and ecosystems.

The **JOURNAL OF AQUATIC PLANT MANAGEMENT** is the official journal of the Aquatic Plant Management Society. This journal deals with "all aspects of aquatic vegetation management, field operations, research, regulations, and reviews." It is published in January and July of each year. Approximately $25.00 per year. For information, contact: Aquatic Plant Management Society, Inc., P.O. Box 16, Vicksburg, Mississippi 39180 USA.

AQUATIC BOTANY is an "international scientific journal dealing with applied and fundamental research on submerged, floating and emergent plants in marine and freshwater ecosystems." It is published in 12 issues per year. Approximately $230 per year. Contact: Elsevier Science Publishers B.V., Journals Department, P.O. Box 211, 1000 AE Amsterdam, THE NETHERLANDS.

ALGAE

by Dr. Ted Batterson, Department of Fisheries and Wildlife, Michigan State University, Rm. 13, Natural Resources Building, East Lansing, Michigan 48824.

The algae are a diverse grouping of plants that occur in a wide range of habitats. They occur on the land and on permanent ice sheets and snowfields, but predominately are found in the waters that cover over 70% of the earth's surface. They are photosynthetic plants that contain chlorophyll, have simple reproductive structures, and whose tissues are not differentiated into true roots, stems, or leaves.

Algae display a variety of growth forms. There are unicellular species, motile (flagellate), non-motile, or amoeboid. There are multicellular species which grow in colonial and filamentous organizations. Colonies are mass aggregations of individuals and filaments are strands of cells that can be either branched• or unbranched. Some algae have such complex growth forms that they can be mistaken for vascular plants. Members of the Charophyte group are an example of this.

Sizes of individual algal plants range from microscopic, unicellular species, approximately 0.000039 inches (0.0010mm) in diameter, to large filamentous marine algae that attain lengths of over 100 ft. (30 m).

HABITS (OR MODES OF EXISTENCE)

Planktonic—free-floating
Benthic—attached and bottom dwelling
Periphytic—attached to rooted aquatic plants
Epiphytic—attached to plants
Epipelic—attached to mud or sand
Epizoic—attached to animals
Epilithic—living on stones

CLASSIFICATION OF ALGAE

The algae are placed into major groups, or divisions, based on the pigments they contain, their storage products, and their morphology (or growth form). Most algal divisions are present in both marine and fresh waters, although some occur more abundantly in one or the other. The *Phaeophyta* (brown algae) and *Rhodophyta* (red algae) are almost exclusively marine, while the *Euglenophyta* (Euglenoids) are almost all freshwater in their distribution.

1. *Phaeophyta* (brown algae)—includes the large kelps, almost exclusively marine.
2. *Rhodophyta* (red algae)—usually quite large, visible to the naked eye, almost exclusively marine.
3. *Batrachospermium* -freshwater.
4. *Euglenophyta* (Euglenoids)—although usually green, can sometimes be colored red because of accessory pigments and can form a bright red film in ponds or sloughs under "bloom" conditions. This red coloration is in response to intense light conditions. *Phacus, Trachelomonas, Euglena.*
5. *Cryptophyta* (Cryptomonads)—closely related to dinoflagellates. *Cryptomonas.*
6. *Pyrrhophyta* (Dinoflagellates)—many in fresh water but the ones which receive the most attention are those that produce "red tides". *Gymnodidium, Ceratium.*
7. *Chrysophyta* (yellow-brown or yellow-green algae). *Chrysophaerella, Mallomonas, Synura.*

The next four groups are the most commonly occuring ones found in freshwater systems:

8. *Bacillariophyta* (diatoms).
   Centrales (radial symmetry): *Cyclotella, Stephanodiscus.*
   Pennales (bilateral symmetry): *Navicula, Mastogloia, Cymbella.*
9. *Charophyta* (Charophytes). *Chara.*
10. *Chlorophyta* (Green algae). *Volvox* (colonial); *Coelastrum; Scenedesmus; Spirogyra* (filament—conjugating); *Eygnema; Hydrodictyon; Desmids; Micrasterius; Oedogonium; Bulbochaeta; Cladophora* (note similarity to *Phithophora); Stigeoclonium.*
11. *Cyanophyta* (blue-green algae). *Microcystis; Oscillatoria; Lyngbya; Cylindrospermium; Glaucocytis; Agnemellum.*

COLLECTION AND PRESERVATION

Phytoplankton can be collected from the open water in one of the following ways:

* With a cone-shaped, silk, bolting cloth net (No. 20 mesh) [available from biological supply houses] and then dispensed into a container.
* With a water sampler (e.g. VanDoran, Kemmerer, etc.) and then dispensed into a container.
* Submersing a bottle, mouth down, some distance below the water surface and then inverting, letting the bottle fill.

For all filled containers leave an air space and to look at live specimens keep chilled. If not, preserve with 3% formalin, 95% alcohol, or I-KI.

For collection of filamentous mats or charophytes procure a sample and place inside of wet newspaper and wrap with dry newspaper; if possible keep chilled.

IMPORTANCE AND BENEFITS OF ALGAE

From a biological perspective algae are of great importance to fresh water and marine environments: 1) they are important in oxygenating the waters, 2) they convert inorganic materials to organic matter, and 3) they serve as the base of the food chain upon which most of the other organisms in the aquatic habitat either directly or indirectly rely.

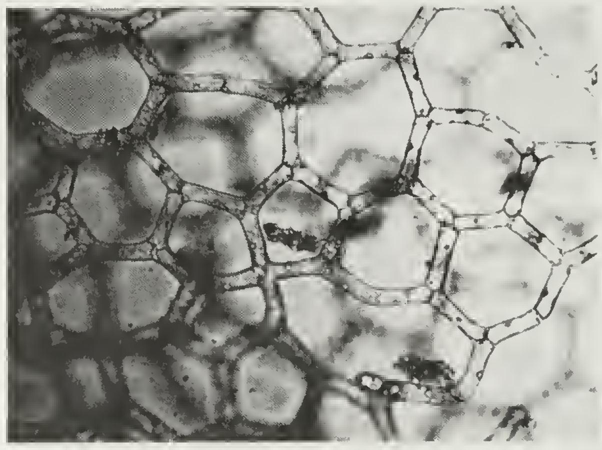
All of this is accomplished through photosynthesis, the process in which energy from the sun is converted to chemical energy in the plant. On a global basis, conservative estimates attribute 50% of all photosynthesis to the algae. In many water bodies they may be the only organisms fixing sunlight, while in others it also may be by vascular plants.

Because algae are at the base of the food chain they are being utilized in fish production systems. Fish culturists fertilize certain water bodies to increase algal biomass, which in turn supports greater animal biomass at other levels of the food chain, and ultimately results in greater fish biomass. Unfortunately, there is no simple formula for how much or what kind of fertilization should be used; results from many undertakings have been variable and quite unpredictable. For example, in some cases fertilization led to blooms of undesirable species such as filamentous blue-green algae which are unpalatable to most organisms that feed on algae.

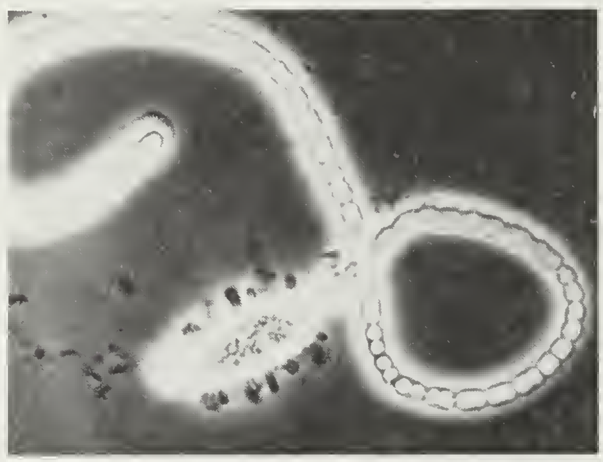
Algae also may be considered beneficial when they grow in high enough density to exclude submersed macrophytes. This is the result of reduced penetration of light by increased turbidity. Aesthetically, this may or may not be preferred to excessive growths of submersed macrophytes.

PROBLEMS CAUSED BY ALGAE

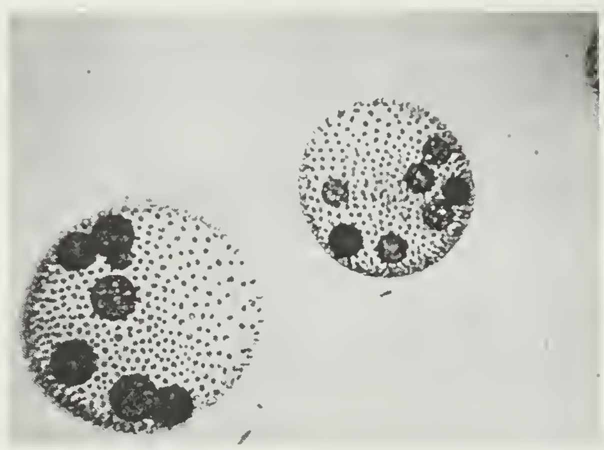
Like all living organisms, the algae require certain conditions for growth. Light, temperature, and the availability of inorganic nutrients are



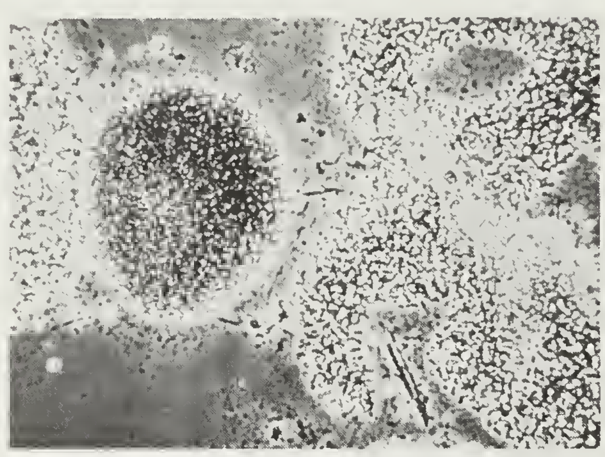
Hydrodictyon



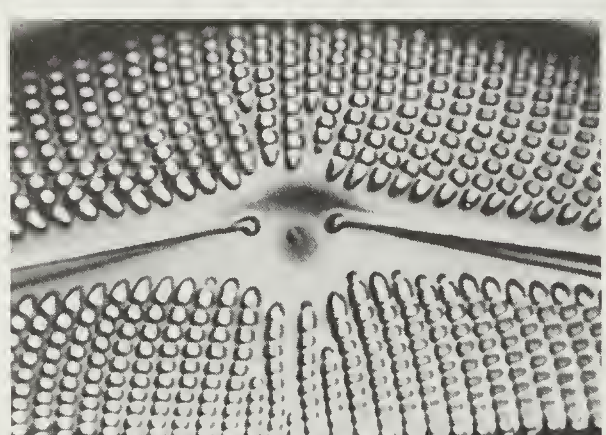
Chrysophaerella



Volvox



Microcystis



Cymbella

three major algal growth parameters. Of these factors, inorganic nutrients seem to be growth limiters for most algae. Increasing the levels of these substances in water can lead to such profuse growth that water quality problems arise, such as undesirable taste and odor, toxicity, and unsightly appearance.

The excessive growth of one or more species of algae is called a "bloom". Usually blooms are due to members of the planktonic blue-green algae. In some cases, blooms can kill aquatic animals, wildlife and livestock.

Death or injury to animals can be due to oxygen depletion or the ingestion of toxins that are released by or contained in the blooming algae. Oxygen depletion is caused by cellular respiration of all organisms of the water body, including algae, especially during the night when there is no photosynthesis and oxygen evolution is not occurring.

CONTROL METHODS

Nutrient Depletion

Probably the best control of algal problems is the control of their growth nutrients. This is also the most difficult control to accomplish. Nutrients can be controlled in the water or by controlling the nutrient runoff from areas surrounding the water body.

Physical Control

Harvesting. The only known in-lake study of algal harvesting as a management practice was conducted in Clear Lake, California in the late 1960's. The removals were made for cosmetic purposes in small bays where blue-green algae were considered obnoxious. An oil skimmer was used to collect the floating blue-green algae which were then pumped through a microstrainer for removal.

Another algae harvesting procedure is pumping lake water to a land disposal site and soil filtering the algae as the water percolates downward and back to the lake.

Habitat Manipulation

Aeration/circulation. This is a mechanical means of keeping a water body constantly mixed and enriched with oxygen. Some studies have shown that this technique can destroy blue-green algal scums by circulating the cells throughout the water. In one study, the total algal biomass remained the same but after circulation the water had become dominated by the more desirable green algae. Other studies showed increased blue-green algae after circulation. Obviously, it is not clear how valuable this management tool can be.

Light reduction. Dyes, such as Aquashade, have been used as a control by reducing the amount of available light. Its use should be restricted to water bodies with little or no outflow since otherwise the dye is flushed away. To be effective the dye must be applied before the algae appear at the surface of the water. Dye will not control algae which originate in shallow water less than one or two feet deep; thus an algaecide may have to be applied in conjunction with an Aquashade treatment.

Flushing. Some algae (particularly the phytoplankton) can be controlled by increasing the washout rate. If the retention time can be reduced to 10 days or less many algae cannot reproduce rapidly enough to create "bloom" conditions.

Carbon dioxide addition. This treatment shifts populations from blue-greens to the more desirable greens.

Biological Controls

Predator-prey relationships. A natural way in which algal populations are kept under control is by predation by zooplankton and small fish. Manipulating these predators can control algae. In Minnesota and Michigan this has been done with some degree of success.

Interspecific manipulations. Certain algae and macrophytes are known to have an antagonistic relationship because they are in direct competition for light and nutrients. It is known that it is possible to control submersed weeds by fertilizing and increasing algal biomass and reducing light to submersed plants. Whether reversing this process is possible is not known but in either case it may only be substituting one problem for another.

Pathological reactions. Parasitism naturally occurs in algal populations. Fungi have been reported to infest diatoms, and bacteria have been isolated that kill or lyse a variety of green or blue-green algae. However, controlling blue-green algal blooms by viruses probably offers a greater potential than fungi or bacteria since many viruses are species-specific. The Russians have done the most work in this area and have controlled blue-green algal blooms with viruses.

Chemical Controls (Algicides)

Most algicides are copper-based, and CuSO4 was first used for phytoplankton control in 1904. Extensive tests have been carried out on this chemical since then but new facts still are being discovered.

Two precautions for applying algicides are especially worth mentioning. The first has to do with the relationship between oxygen and temperature. Less oxygen is held in warm water. Algal die-off can quickly consume all oxygen in the water if too large an area during warm water conditions is treated.

The second precaution has to do with copper toxicity. Cooper has a low mammalian toxicity but a rather high one to fish and fish-food organisms. The toxicity is increased depending on whether it is soft or hard water, where soft water is defined as $<$50 mg CaCO3/L (ppm) and hardwater $>$100 mg CaCO3/L (ppm). The acute oral lethal concentration (LC50) for bluegill fish in softwater is 1 ppm Cu while in hardwater it is 7 ppm Cu.

The effectiveness of CuSO4 is severely limited in hardwater lakes because CaC03 combines with it to form an insoluble precipitate of cooper basic carbonate. Chelated CuSO4, which does not precipitate as readily, is often used in hard water lakes but is more expensive. Other algicides are usually more expensive but do not necessarily provide better control.

MEETINGS

13TH BIENNIAL INTERNATIONAL CONFERENCE, THE INTERNATIONAL ASSOCIATION ON WATER POLLUTION RESEARCH AND CONTROL (IAWPRC). August 17-22, 1985, Rio de Janeiro, BRAZIL. It will be the first IAWPRC conference held in Latin America. Included in the general session will be papers dealing with all aspects of water pollution research, treatment and control. Seminars of special interest, including one on the "Use of Macrophytes in Water Pollution Control at Sao Paulo" also will be included. Special themes for the conference are "Research in sewage treatment technology for developing countries", "Application of low-cost waste management techniques for developing countries" and "Education and training in water pollution control". For more information, contact Mr. Anthony Milburn, Executive Director IAWPRC, Alliance House, 29/30 High Holborn, London WC1V 8BA, UNITED KINGDOM.

INTERNATIONAL SYMPOSIUM ON AQUATIC MACROPHYTES. August 26-30, 1985, Silkeborg, DENMARK. (See announcement in Fall 1984 AQUAPHYTE, V.4 no. 2.)

10TH CONFERENCE OF THE ASIAN-PACIFIC WEED SCIENCE SOCIETY. November 24-30, 1985, Chiang Mai Orchid, Chiang Mai, THAILAND. The program theme will be "Weeds and Environment in the Tropics" and will include papers on weed ecology, biology and control, as well as papers on new herbicides and technology transfer. A field trip will include a visit to an area infested by *Mimosa pigra*. For more information, contact Miss Maneesa Teerawatsakul, Secretary, Working Committee for 10th Conference of APWSS, c/o Botany and Weed Science Division, Department of Agriculture, Bangkhen, Bangkok 10900, THAILAND.

7TH INTERNATIONAL SYMPOSIUM ON AQUATIC WEEDS. September 15-19, 1986, Loughborough, ENGLAND. (See announcement elsewhere in this issue.)

25TH ANNUAL MEETING OF THE AQUATIC PLANT MANAGEMENT SOCIETY. July 21-24, 1985, Vancouver, British Columbia, CANADA. For more information, contact Mr. W.N. Rushing, P.O. Box 16, Vicksburg, Mississippi 39182. (601) 636-3111, ext. 3542.

FIRST INTERNATIONAL SYMPOSIUM ON WATERMILFOIL (*MYRIOPHYLLUM SPICATUM*). July 23, 1985, Vancouver, British Columbia, CANADA. The Symposium will feature invited papers on the distribution, ecology, physiology and management of watermilfoil and related species. For more information, contact Mr. W.N. Rushing, P.O. Box 16, Vicksburg, Mississippi 39182 (601) 636-3111, ext. 3542.

BOOKS/REPORTS

THE BIOLOGY OF AQUATIC VASCULAR PLANTS by C.D. Sculthorpe. 1967. 1971. 1985.

This volume, the classic in its field, is out-of-print and very difficult to find. However a newly revised edition is scheduled for publication this year. The price will be about $40.00 (US). For more information, contact Koeltz Scientific Books, P.O. Box 1360 & 1380, D-6240 Koenigstein, FEDERAL REPUBLIC OF GERMANY.

GROWTH PERFORMANCE, NUTRIENT UPTAKE AND HUMAN UTILIZATION OF DUCKWEEDS (LEMNACEAE FAMILY). by G. Bjorndahl. 1984. University of Oslo and the Agriculutral Research Council of Norway, Fytotronanlegget, Postboks 1066 Blindern, Oslo 3, NORWAY. 102 pages.

This English language review is about the practical utilization of duckweed biomass. It includes chapters on growth, photosynthesis and metabolism of duckweeds and biotic effects on their growth, and includes a long "references" list.

HERBICIDE MANUAL. A Guide to Supervise Pest Management and to Train O&M Personnel. by G.W. Hansen, F.E. Oliver and N.E. Otto. 1983. U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado. 346 pages. Order from: Bureau of Reclamation, Attn D-922, P.O. Box 25007, Denver, Colorado 80225-0007, USA. $9.00

This manual is a complete reference for field operation and maintenance personnel responsible for weed

(Continued on page 8)

PLANTS AND DISEASES

(Continued from page 1)

Lemna spp. (Thomas, 1982, 1983; Brown, 1973); *Salvinia auriculata* (Hira, 1969; Brown, 1973); *Nymphaea* (Wright, 1956; Cantrell, 1981); and *Pistia stratiotes* (Betterton, 1984). In laboratory studies, *Biomphalaria glabrata* has been shown to thrive on *Groenlandia densa* and *Potamogeton crispus* (Thomas, 1983). *A. vinosa* has been found living in *Spirogyra* algae as well (Blair, 1981).

Some plants do more than provide refuge and physiological benefits to snails; they also transport them throughout water systems. Increased incidence of diseases has been attributed partly to new irrigation and other vital water projects which frequently become quickly filled and covered with aquatic plants. Floating mats of *Salvinia auriculata* are believed responsible for quickly spreading snail hosts throughout the Lake Kariba system (Brown, 1973). Brown also blamed a 1967-68 sharp rise in schistosomiasis at Lake Kariba on high densities of *Bulinus truncatus* snails developing in *Ceratophyllum* and called for increased water management to control the disease. Controlling *Salvinia auriculata* was recommended by Hira (1969) as a way to control schistosomiasis outbreaks around Lake Kariba. In another example, the Lake Chad irrigation system was infested by snail hosts of schistosomiasis even before it was completed. Within a year of opening the sandy bottomed southerly reaches of the Lake Chad system, four species of schistosome snail vectors had appeared. They were transported on floating islands of *Pistia* brought by a strong northerly wind (Betterton, 1984).

The Thomas and Tait study (1984) discussed several integrated snail control measures including: "prevent immigration of both macrophytes and snails from feeder streams", control submersed and emergent plants, and "replace key marginal macrophytes". Coates (1984) suggested an integrated control plan using fishes to control weeds, snails and mosquitoes in Sudan. Dawood (1965) used 2,4-d, diquat and dalapon to control aquatic plants and their snail disease vectors. In a Wisconsin lake, Engel (1984) reported that the first year of harvesting *Potamogeton* also harvested 3,200,000 (non-vector) snails per acre; the second year harvest found only 45,000 snails per acre. Ferguson (1971) said that controlling weeds would enable more effective use of molluscicides and insecticides.

MOSQUITOES

Aquatic plants also are known to be essential to the life-cycles of several kinds of disease carrying mosquitoes. Mosquitoes use plants as egg-laying sites, sources of oxygen and protection for larval nurseries. *Eichhornia crassipes, Pistia stratiotes, Sagittaria, Typha, Salvinia* and *Lemna* all have been shown to be attractive to certain mosquitoes (Wilson, 1967; Gass, *et al.*, 1983; Burton, 1960).

Hinman (1938) stated that if certain aquatic plants were controlled or removed, "the problem of malaria control could be practically solved". Wilson (1967) said that control of *Pistia, Sagittaria, Typha* and *Salix* must be an "integral part of mosquito control programs." Seabrook (1962) reported that water hyacinth control contributes greatly toward controlling *Mansonia* and *Culex* mosquitoes. Mulrennan (1962) observed that two species of *Mansonia* were almost "totally dependent on *Pistia stratiotes*" and that *Mansonia* could "only be controlled at the source" by controlling *Pistia*. Others have suggested that water management including aquatic plant control should be part of mosquito-transmitted disease control (Hess, 1944; Hofstede, 1950; Chow, 1955; McLaren, 1967; Ferguson, 1971; Brown, 1973; Legner, 1973, 1978; Coates, 1981, 1984; Gass, 1983; Hudson, 1984). As for salt marsh mosquitoes, Whigham *et al.* (1982) stated that water management techniques control mosquitoes and reduce the need for insecticides. They discuss Open Marsh Water Management (OMWM) as a technique to control salt marsh mosquitoes.

In the database, almost no research was found which shows the numerical effects of aquatic plant control on mosquito populations. However, some work has been published on different methods of control of mosquito host plants using herbicides, fish and manatees. [Of course, much research not specifically related to mosquito control has been published about the control of the host-plants cited herein. Bibliographic lists of this research also are available from the Aquatic Weed Program.]

In 1957, Neogy *et al.* used 2,4-d to control plants in mosquito breeding sites in an attempt to control malaria transmission in India. In Panama, manatees were used to control mosquito host plants (McLaren, 1967). In California, Legner (1980) reported that *Culex tarsalis* was controlled by the weed-eating fish *Tilapia zillii* which ate *Potamogeton pectinatus* and *Myriophyllum spicatum* in rapidly flowing irrigation canal systems. In 1973, Legner also reported that *Tilapia* greatly reduced mosquito larvae by direct predation.

It is known that some aquatic sites which might be expected to harbor large numbers of mosquitoes have very few. Researchers attempting to explain this phenomenon have found that certain plants produce substances which are toxic to mosquitoes and their larvae, and some plants even "eat" them. In 1931, C.R. Twinn reported that under some conditions, the alga *Chara fragilis* controls mosquitoes. He also noted that the aquatic bladderwort *Utricularia macrorhiza* readily traps mosquito larvae in all stages of development. Recently, extracts from *Myriophyllum spicatum* have been shown to be somewhat toxic to larvae of *Aedes aegypti, Culex tarsalis* and *C. quinquefasciatus* (Schulz, *et al.*, 1982). Dhillon *et al.* (1982) reported that extracts of *M. spicatum* induced mortality and also delayed the rate of development of *Culex quinquefasciatus, C. incidens* and *Aedes aegypti,* and concluded that the plant "growing profusely in stagnant water has inhibitory effects on mosquitoes and midges." An extract from *Lemna minor* significantly deterred egg-laying of *Aedes aegypti* but was ineffective against *Culex pipiens* (Judd, 1980). In tank studies, Angerilli *et al.* (1974) found 100% mortality of *Aedes aegypti* larvae in *chara globularis*, 74% mortality in *Lemna minor* and 100% in *Utricularia minor*. They also found *Elodea canadensis* to be "inimical to the development and survival of mosquito larvae", and that *Hydra* on the stems of *Callitriche palustris* caused 100% mortality of larvae. In 1977, Angerilli reported that *Lemna minor* "clearly deters *Culex pipiens* infestations of ponds in nature."

Some plants are believed simply to present a physical barrier against mosquito development. Hobbs and Molina (1983) reported that *Salvinia auriculata* has a marked inhibitory effect on *Anopheles alalbimanus* breeding in Guatemala, and suggested that *Salvinia* be transplanted to selected permanent breeding sites. And Smith (1910) suggested transplanting *Azolla* as a mosquito control in New Jersey marshes.

It is believed that controlling certain aquatic plants should be part of water-based disease control programs. Much research information exists on the various methods of controlling aquatic plants and citation lists of the literature are available free of charge from the Aquatic Weed Program.

V.R.

Angerilli, N.P.D. 1980. Influences of extracts of freshwater vegetation on the survival and oviposition by *Aedes aegypti* (Diptera: culicidae). Can. Entomol. 112(12):1249-1252.

Angerilli, N.P.D. 1974. Influences of some freshwater plants on the development and survival of mosquito larvae in British Columbia. Can. J. Zool. 52:813-815.

Angerilli, N.P.D.; N.P. Beirne. 1982. Mortality of introduced mosquito larvae in natural and artificial ponds containing aquatic vegetation. Prot. Ecol. 4:381-386.

Barber, M.A.; T.B. Hayne. 1925. Water hyacinth and the breeding of *Anopheles*. U.S. Public Health Serv. Rept. 40(47):2557-2562.

Barber, M.A.; T.B. Hayne. 1925. Water hyacinth and the breeding of *Anopheles*. U.S. Public Health Serv. Rept. 40(47):2557-2562.

Betterton, C. 1984. Ecological studies on the snail hosts of schistosomiasis in the South Chad Irrigation Project Area, Borno State, Northern Nigeria. J. Arid Environ. 7(1):43-57.

Blair, D.; C.M. Finlayson. 1981. Observations on the habitat and biology of a Lymnaeid snail, *Austropeplea vinosa* (Gastropoda: Pulmonata), an intermediate host for avian schistosomes in tropical Australia. Aust. J. Mar. Freshwater Res. 32:757-767.

Bousfield, J.D. 1979. Plant extracts and chemically triggered positive rheotaxis in *Biomphalaria glabrata* (Say), snail intermediate host of *Schistosoma mansoni* (Sambon). J. Appl. Ecol. 16:681-690.

Brown, A.W.A.; J.O. Deom. 1973. Summary: Health aspects of man-made lakes. In: Man-Made Lakes: Their Problems and Environmental Effects, ed. by W.C. Ackermann, G.F. White and E.B. Worthington. Amer. Geophysical Union, Washington, D.C. pp. 755-764.

Burton, G.J. 1960. Studies on the bionomics of mosquito vectors which transmit filariasis in India. II. The role of water hyacinth (*Eichhornia speciosa* Kunth) as an important host plant in the life cycle of *Mansonia uniformis* (Theobald) with notes on the differentiation of the late embryonic and newly hatched stages of *Mansonia uniformis* (Theobald) and *Mansonia annulifera* (Theobald). Indian J. Malariology 14(2):81-105.

Cantrell, M.A. 1981. Bilharzia snails and water level fluctuations in a tropical swamp. Oikos 36(2):226-232.

Chow, C.Y.; E.S. Thevasagayam; E.G. Wambeek. 1955. Control of *Salvinia*— a host of *Mansonia* mosquitoes. Bull. Wld. Hlth. Org. 12:365-69.

Coates, D.; T.A. Redding-Coates. 1981. Ecological problems associated with irrigation canals in the Sudan with particular reference to the spread of bilharziasis, malaria and aquatic weeds and the ameliorative role of fishes. Intern. J. Environmental Studies 16:207-212.

Coates, D. 1984. A survey of the fish fauna of Sudanese irrigation system with reference to the use of fishes in the management of ecological problems (the control of aquatic weeds, malarian and infective schistosomiasis.) Fish. Mgmt. 15(3):81-96.

Crossland, N.O.; W.M. Adams. 1963. The use of acrolein for the control of aquatic weeds and snails in an irrigation system in Tanganyika. Pest. Abstr. C. 9(3):221-224.

Dawood, I.K. 1965. Herbicide trails in the snail habitats of the Egypt 49 project. Bull. Wld. Hlth. Org. 32:269-287.

Dhillon, M.S.; M.S. Mulla; Y.-S. Hwang. 1982. Allelochemics produced by the hydrophyte *Myriophyllum spicatum* affecting mosquitoes and midges. J. Chem. Ecol. 8(2):517-526.

Engel, S. 1984. Plant harvesting evaluated in Iowa County. DNR Digest, April 1984, p. 4.

Ferguson, F.F. 1971. Some current controls for aquatic weeds inimical to public health. E. African Med. J. 48(8):456-459.

Gabaldon, A. 1952. The effect of DDT on the population of anopheline vectors in Venezuela. Riv. Parassit. 13:29-41.

Gass, R.F.; T. Deesin; K. Surathin; S. Vutikes; S. Sucharit; C. Harinasuta. 1983. Studies on oviposition characteristics of *Mansonia (Mansonioides)* mosquitoes in southern Thailand. Annals of Tropical Medicine and Parasitology 77(6):605-614.

Hess, A.D.; T.F. Hall. 1945. The relation of plants to malaria control on impounded waters with a suggested classification. J. Nat. Malaria Soc. 4(1):19-45.

Hira, P.R. 1969. Transmission of schistosomiasis in Lake Kariba, Zambia. Nature 224(5220):670-672.

Hobbs, J.H.; P.A. Molina. 1983. The influence of the aquatic fern *Salvinia auriculata* on the breeding of *Anopheles albimanus* in coastal Guatemala. Mosquito News 43(4):456-459.

Hofstede, A.E.; F. Botke. 1950. *Tilapia mossambica* Peters as a factor in malaria control in the vicinity of Djakarta. Landbouw 22:453-468.

Hudson, J.E. 1984. *Anopheles darlingi* Root (Diptera: Culicidae) in the Suriname rain forest. Bull. Ent. Res. 74:129-142.

Judd, G.J.R.; J.H. Borden. 1980. Oviposition deterrents for *Aedes aegypti* in extracts of *Lemna minor*. J. Entomol. Soc. British Columbia. 77:30-33.

Legner, E.F.; R.A. Medved. 1973. Influence of *Tilapia mossambica* (Peters), *T. zillii* (Gervais) (Cichlidae) and *Mollienesia latipinna* le sueur (Poeciliidae) on pond populations of *Culex* mosquitoes and Chironomid midges. Mosquito News 33(3):354-364.

McDonald, J.L.; L.C. Lu. 1973. Preference of *Mansonia uniformis* (Theob.) for specific water hyacinth plants. Mosquito News 33(3):466-467.

McLaren, J.P. 1967. Manatees as a naturalistic biological mosquito control method. Mosquito News 27:387-393.

Mulrennan, J.A. 1962. The relationship of mosquito breeding to aquatic plant production. Hyacinth Control J. 1:6-7.

Neogy, B.P.; P. Kachroo; K. Biswas. 1957. Aquatic vegetation of Bokaro Reservoir in relation to anopheline mosquito larvae and its control by application of herbicides. Indian J. Malariology 11(2):191-212.

Pip, E.; J.M. Stewart. 1976. The dynamics of two aquatic plant-snail associations. Can. J. Zool. 54:1192-1205.

Schultz, G.W.; Y.-S. Hwang; M.S. Mulla. 1982. Toxicity and attractancy of the hydrophyte *Myriophyllum* against mosquitoes. Proc. & Papers Ann. Conf. of the Calif. Mosquito & Vector Control Assoc. (50th), p. 68-69.

Seabrook, E.L. 1962. The correlation of mosquito breeding to hyacinth plants. Hyacinth Control J. 1:18-19.

Smith,J.B. 1910. *Azolla* vs. mosquitoes. Ent. News 21:437-441.

Sterry, P.R.; J.D. Thomas; R.L. Patience. 1983. Behavioural responses of *Biomphalaria glabrata* (Say) to chemical factors from aquatic macrophytes including decaying *Lemna paucicostata* (Hegelm ex Engelm). Freshwater Biol. 13:465-476.

Thomas, J.D. 1982. Chemical ecology of the snail hosts of schistosomiasis: snail-snail and snail-plant interactions. Malacologia 22(1-2):81-91.

Thomas, J.D.; B. Grealy; C.F. Fennell. 1983. The effects of varying the quantity and quality of various plants on feeding and growth of *Biomphalaria glabrata* (Gastropoda). Oikos 41:77-90.

Thomas, J.D.; A.I. Tait. 1984. Control of the snail hosts of schistosomiasis by environmental manipulation: a field and laboratory appraisal in the Ibadan area, Nigeria. Phil. Trans. R. Soc. Lond. B 305:201-253.

Twinn, C.R. 1931. Observations on some aquatic animal and plant enemies of mosquitoes. Can. Entomol. 63:51-61.

Wilson,F. 1967. The role of aquatic weeds in mosquito control. Hyacinth Control J. 6:26.

AQUATIC PLANT INFORMATION AND RETRIEVAL CENTER

The Aquatic Weed Information and Retrieval Center collects information relating to freshwater aquatic plants and provides bibliographies of the literature to those who request them. Any researcher or government entity anywhere is eligible to use the service, and in most cases there is no charge to the user.

More than 20,000 articles and books, dating from the 1700s, have been catalogued by the program staff. Approximately 250 new items, most contributed by their authors, are received by the program each month.

The citations and keywords of the literature are entered into a computerized database. Computer generated bibliographies, corresponding to any combinations of species names, categories and keywords of the user's choice, are produced and mailed to users in 65 countries. About 2,000 bibliographies are mailed to users each year. These include "retrospective searches" and "current awareness updates". More than 800 individuals receive updates every six months.

The program requests publications and publications lists concerning all aspects of freshwater aquatic plant ecology, biology, control and utilization. Reprints are especially welcome.

To learn more about the information services provided, contact the Aquatic Weed Program, 2183 McCarty Hall, University of Florida, Gainesville, Florida 32611, U.S.A. (904) 392-1799.

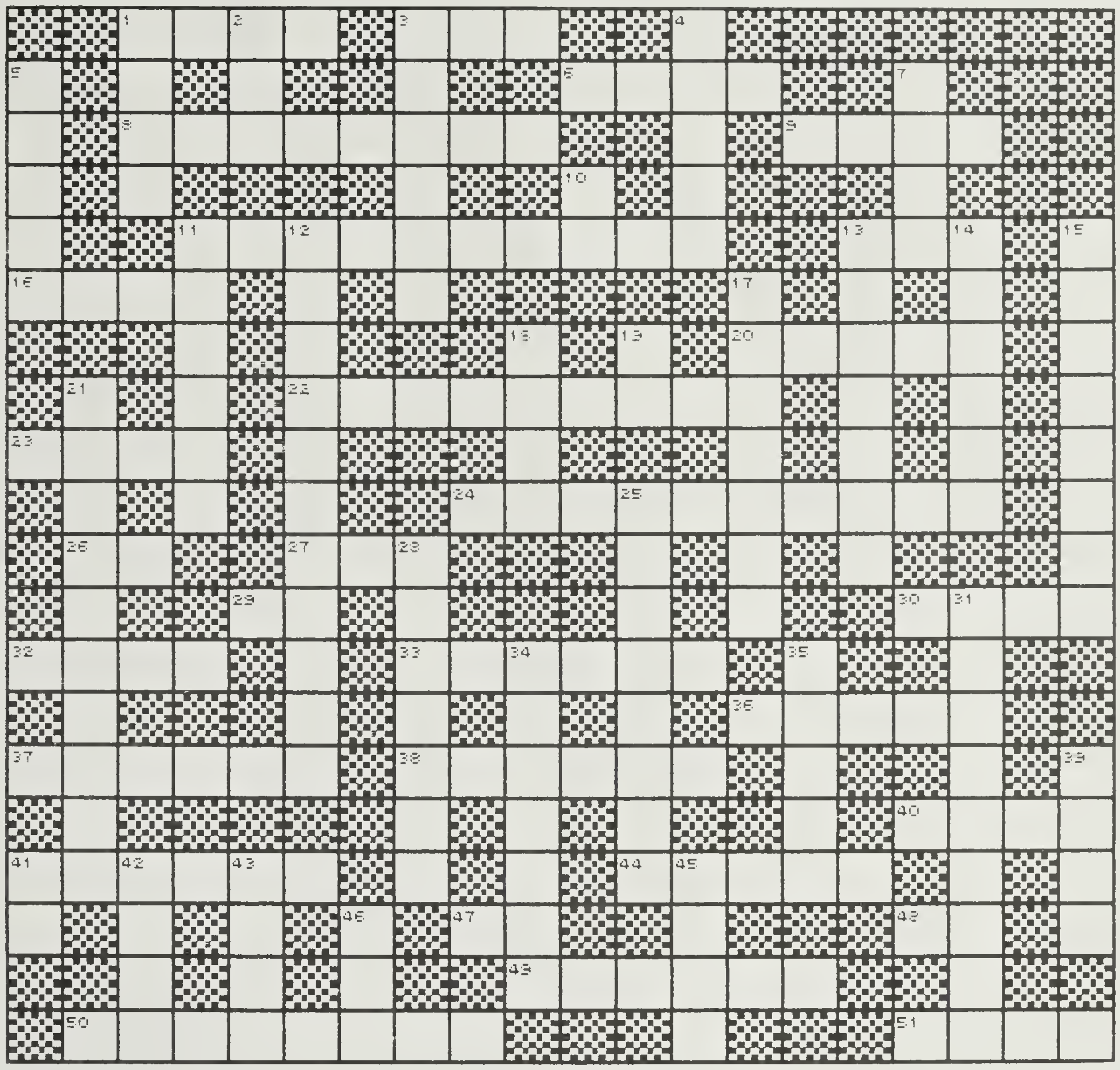
SPECIAL THANKS

The Aquatic Plant Database solicits contributions of articles and books from its users and more than half of the items cited in the database have been contributed by several hundred people. Recently, though, we have received very large contributions of aquatic plant literature from three.

Special thanks go to:
Dr. Alva Burkhalter
Dr. E.O. Gangstad
Mrs. William (Jo) Maier

Below are some subjects retrievable from the aquatic plant database and the approximate number of articles cited as of May, 1985:

Alternanthera philoxeroides since 1975	*169*
Eichhornia crassipes since 1975	960
Hydrilla verticillata since 1975	572
Myriophyllum spicatum since 1975	492
Salvinia spp. since 1975	284
Alternanthera and biological control	213
Eichhornia and utilization	464
Hydrilla and chemical control	226
Lemna and physiology	606
Salvinia and chemical control	129
Biological control since 1975	1085
Chemical control since 1975	995
Mechanical control since 1975	261
Utilization of macrophytes since 1975	1049
Biogas from macrophytes	159
Ecology and herbicides	664
Fish as biological controls	786
Insects as biological controls	579
Pathogens as biological controls	272
Pollution and macrophytes	965



ACROSS CLUES

1. Some aquatic plants have been ensiled to make ' '.
3. U.N. Agency based in Rome (abbr.)
6. Common name of *Phragmites*
8. "Kariba weed"
9. Submersed plants are consumed by the grass ' '.
11. Disease vectors associated with some aquatic plants
13. "Ultimate cell"
16. North-flowing river with aquatic weed problems
20. Any pointed projections in plants
22. Active ingredient of the herbicide Sonar
23. Building block of plant and animal bodies
24. Genus name of water hyacinths
26. Widely-used algicide (chem. abbr.)
27. Thin layer chromatography
29. Hectare (abbr.)
30. A reproductive unit
32. *Salvinia* is a floating ' '.
33. Duck potatoes
36. Stem and leaves
37. Methane from aquatic plants
38. Ancient Chinese "biofertilizer"
40. Bottom part of *Nuphar* plant
41. Lake and dam on the border of Zambia and Zimbabwe
44. Non-vascular photosynthetic plants
47. Total solids (abbr.)
48. Measure of concentration of hydrogen ions
49. Disk used to measure light penetration
50. Marshes, swamps, bogs, fens
51. 2.471 of these is a hectare

DOWN CLUES

1. *Ctenopharyngodon idella* is a ' '.
2. *Vallisneria* and *Zostera* are sometimes called ' 'grass.
3. *Cercospora* is a ' ' which attacks water hyacinths.
4. Unwanted plants
5. North African country with aquatic weed problems
7. Aquatic cereal research group based in Philippines (abbr.)
10. Dissolved oxygen (abbr.)
11. Cadmium, lead, mercury, zinc
12. Surface active agents
13. Overwintering buds
14. The Bartrams found this plant in Florida in 1765
15. Sterile grass carp
17. Widely-used class of broadleaf herbicides
18. South Pacific island group
19. Molybdenum (chem. abbr.)
21. Weevil biological control of water hyacinths
25. Major aquatic weed spreading in U.S.
28. *Typha*
31. Nutrient rich
34. Weight of organisms per unit area
35. Genus of filamentous algae
39. Main axis of plant
41. 1000 grams (abbr.)
42. Headquarters of U.N. Food and Agricultural Organization
43. Part of a bird's jaw
45. Plural of locus
46. Conductivity measures ' ' content of water.

If you would like to make a crossword puzzle, send 100 words and their clues to the Aquatic Weed Program. We will construct it (by computer) and return it to you.

EASY TO GET REPORTS

What are the "NTIS Numbers" listed on some citations from the Aquatic Weed Program and other databases? They are accession numbers which make it easy to obtain copies of government sponsored research reports from a single source.

The **National Technical Information Service** (NTIS) is an agency of the U.S. Department of Commerce. NTIS collects technical research sponsored by many U.S. government departments and agencies and disseminates them from one place. NTIS provides several kinds of information services including published searches of the literature of technical subjects and a computer database of government sponsored research publications.

For free information on NTIS services, including its 28 abstract newsletters, database services and technical note services, or to order any report which features an "NTIS Number", contact: U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161, USA, (703) 487-4630.

NONPROFIT ORG

GAINESVILLE FLA.

US POSTAGE

PB METER 6102495

AQUATIC WEED PROGRAM
2183 McCarty Hall
University of Florida
Gainesville, FL 32611 USA
(904) 392-1799

Dr. Marianne Block
Serials and Exchange
The New York Botanical Garden
Bronx, New York 10458

STERILE GRASS CARP BEING CULTURED

Several new fish culturing studies are underway at University of Florida fish research facilities. They include intensive larval rearing studies of the sterile grass carp, the hybrid striped bass and the "red tailed shark". Research biologists Mr. Roger Rottmann and Mr. Rick Aldridge are in charge of these projects, under the direction of Dr. Jerome Shireman of the Center for Aquatic Weeds.

The fish research facilities include indoor and outdoor spawning and rearing tanks as well as twenty ponds. Twenty more ponds soon will be under construction with more to be added later. The facilities are located in the Austin Carey State Forest near Gainesville.

One project is to develop methods to intensively culture sterile (triploid) grass carp (*Ctenopharyngodon idella*). Devising methods which would consistently assure the production of large numbers of non-reproducing grass carp would be a major step toward the general utilization of the weed-eating fish for weed control.

According to Rottmann, carp eggs are "temperature shocked" to induce sterility by immersing eggs in warm or cold baths at regular intervals. This treatment causes each egg to retain an additional set of chromosomes. Each egg produces a sterile fish. Rottmann and Aldridge manipulate zooplankton populations to assure a constant supply of food for the young fry which are grown to a size where it is possible to take blood samples to verify ploidy.

In other current fish culture work, Rottmann and Shireman are finding ways to intensively rear the hybrid striped bass (the "sunshine bass") for stocking reservoirs and rivers. This fish is a hybrid between the striped bass and the white bass and is highly prized as a sport and food fish in Florida. The biologists are using cultured nematodes ("microworms") as a first food for hybrid striped bass larvae.

One feature of the fish culture laboratory is its "biofiltering" system for the indoor spawning and rearing tanks. All water is circulated from the indoor tanks to two outdoor ponds where it flows through water hyacinths and cattails before being pumped back to the indoor tanks. The system was designed by Rottmann and has been in successful operation for several years. He calls the system "very useful, simple, reliable and cheap".

Rottmann, Aldridge and Shireman may be contacted at: Center for Aquatic Weeds, IFAS, University of Florida, 7922 N.W. 71st Street, Gainesville, Florida 32606 USA. (904) 376-0732.

BOOKS/REPORTS

(Cont'd. from page 5)

management on western U.S. water projects. It is used in pest management training courses sponsored by the Bureau of Reclamation and includes chapters on weeds, herbicide classification, factors affecting plant control, application methods, calibrations and calculations. Indexes to products and plants are included.

LEVER-OPERATED KNAPSACK SPRAYERS. A Practical Scrutiny and Assessment of Features, Components, and Operation—Implications for Purchasers, Users, and Manufacturers. by H.H. Fisher and A.E. Deutsch. 1985. International Plant Protection Center (IPPC), Oregon State University, Corvallis, Oregon 97331 USA. IPPC Document No. 53-A-84. 32 pages.

This illustrated booklet was prepared to help persons, particularly in developing countries, make better informed choices when considering the purchase of lever-operated knapsack (LOK) sprayers, and to improve manufacturer development and user utility of the machines. The authors considered 37 LOK sprayers in preparing the book which presents information on the design and construction of LOK sprayers, and examines their operation, practical use, ergonomics and safety.

SPORES AND POLLEN. PTERIDOPHYTES, GYMNOSPERMS, MONOCOTYLEDONS. Flora of the European Part of the U.S.S.R. by A.E. Bobrov, L.A. Kupriyanova, M.V. Litvintsyeva and V.F. Tarasyevich. 1983. Academiya Nauk USSR, Botanical Institute, V.L. Komarova, Leningrad. 208 pages. (In Russian)

This keyed identification manual describes the spores and pollen of 170 species of plants, including about 50 aquatic plants. Most are pictured in hundreds of drawings and microphotographs.

***HYDRILLA VERTICILLATA* IN THE TIDAL POTOMAC RIVER, MARYLAND, VIRGINIA, AND THE DISTRICT OF COLUMBIA, 1983 and 1984.** 1985. by N.B. Rybicki, V. Carter, R.T. Anderson and T.J. Trombley. U.S. Geological Survey, Open-File Report 85-77. Copies can be purchased from: Open-Files Services Section, Western Distribution Branch, U.S. Geological Survey, Box 25425, Federal Center, Denver, Colorado 80225 USA.

"This report summarizes the data on distribution of *Hydrilla* in 1983 and 1984, as well as biomass and tuber production of *Hydrilla* in 1984. It also presents observations made in 1984 regarding competition with other species."

EVALUATION OF BIOLOGICAL, CHEMICAL AND MECHANICAL AQUATIC VEGETATION CONTROL UPON FISH POPULATIONS IN 0.2 HA RESEARCH PONDS. Final Report. by J.V. Shireman, D.E. Canfield, D.E. Colle, D.F. DuRant and W.T. Haller. 1984. 46 pages. Center for Aquatic Weeds, Institute of Food and Agricultural Sciences, Univeristy of Florida, Gainesville.

This is a study of the effects of various control methods on bluegill and bass populations in Florida fish ponds. Twenty 0.2 hectare ponds were managed at different vegetation levels for four years prior to the control tests. Various ponds were treated with herbicides, grass carp, fertilization or mechanical controls. Control effects on fish biomass and direct costs of each control method were calculated.

THE DISTRIBUTION, IDENTIFICATION, BIOLOGY AND MANAGEMENT OF EURASIAN WATER MILFOIL: AN ALBERTA PERSPECTIVE. by E.C. Stockerl and R.L. Kent. 1984. 89 pages. Alberta Environment, Pollution Control Division, Alberta, CANADA.

This is a review of the literature of *Myriophyllum spicatum* history, distribution, biology, identification and control. They conclude that the most effective milfoil control is public awareness and public cooperation in preventing the spread of the noxious plant.

CROSSWORD ANSWERS (see page 7)

		F	E	E	D		F	A	O			W							
S		I		E			U			R	E	E	D			I			
U		S	A	L	V	I	N	I	A			E		C	A	R	P		
D		H					G			O		D				R			
A			M	O	S	Q	U	I	T	O	E	S			T	I	P		T
N	I	L	E		U		S						F		U		I		R
			T		R				F		M		H	O	R	N	S		I
	N		A		F	L	U	R	I	D	O	N	E		I		T		P
C	E	L	L		A				J				N		O		I		L
	O		S		C			E	I	C	H	H	O	R	N	I	A		O
	C	U			T	L	C				Y		X		S				I
	H			H	A		A				D		Y			S	E	E	D
F	E	R	N		N		T	U	B	E	R	S		C			U		
	T				T		T		I		I		S	H	O	O	T		
B	I	O	G	A	S		A	Z	O	L	L	A		A			R		S
	N						I		M		L			R		R	O	O	T
K	A	R	I	B	A		L		A		A	L	G	A	E		P		E
G		O		I		I		T	E			O				F	H		M
		M		L		O			S	E	C	C	H	I			I		
	W	E	T	L	A	N	D	S				I				A	C	R	E